Recent Experience with Hemodialysis in Acute Renal Failure, Chronic Renal Disease with Reversible Features, and in Conjunction with Renal Homotransplants

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During the past 10 years, hemodialysis has progressed from a dangerous procedure requiring one or more physicians in constant attendance, to a safe nurse-technician activity. Similarly, the indications for initiating dialytic therapy have changed as the procedure has been simplified and made almost completely innocuous. It is now felt that one should not wait for the patient to develop advanced uremia before placing him on the artificial kidney, but instead one should use this newer method of treatment before the complications of uremia set in. But dialysis should not be looked upon as a substitute for good medical management; on the contrary, predialytic management is more important now than ever. The most important use for dialysis remains in acute renal failure. More recently, however, it has been used for the maintainance of life in chronic uremia (Pendras and Drickson, 1965; Gombos et al., 1964), the treatment of many cases of poisoning (Maher and Schreiner, 1965) and to support renal homotransplantation (Bower and Magee, 1964).

At the Medical College of Virginia (MCV) the great majority of dialyses have been done in conjunction with the transplant program now under way (Hume et al., 1964). In addition, there has been a significant increase in the number of dialyses done for acute renal failure and poisoning. There has been no dialysis done for the maintainance of life in chronic uremia. The purpose of this paper is to give a brief resumé of the development of the artificial kidney unit at MCV, and to report on the results of its use.

It has been less than 15 years since MCV acquired its first artificial kidney machine. This cumbersome and complicated monster was referred to affectionately as the "rotating drum." It required several physicians to operate it but it did give all those involved with its operation considerable confidence and encouragement that dialysis did work. The next machine that was purchased was the twin coil kidney. This instrument greatly simplified the procedure of dialysis and aroused the interest of many workers in the field both at MCV and throughout the world. The greatest burst of enthusiasm for dialysis at MCV occurred in the fall of 1962 when it was decided to undertake studies in renal homotransplantation in man. The dialysis facilities at that time consisted of the twin coil machine and peritoneal lavage. This latter method of dialysis had recently enjoyed a rejuvenation with the appearance on the market of commercially available prepackaged sterile peritoneal dialysis fluid.

It soon became apparent that both of these methods of dialysis could not meet the demands of the transplant program. For this reason, in January of 1963, the hospital purchased its first Kiil kidney (Kiil, 1960). This machine was designed originally to replace the human kidney during acute renal failure. Later it was found to be well suited for the maintainance of life in chronic uremia and it is today used in the majority of successful chronic dialysis programs. After few modifications it was found that it was likewise made suitable for supporting a transplant program. The next major advance in the dialysis program at MCV again grew out of necessity. The kidneys were being operated in several different areas of the hospital, inefficiently. It became apparent that larger and more permanent quarters were needed to meet the ever-increasing demands of the transplant program as well as the increasing volume of acute dialysis. In the fall of 1964, the present dialysis unit was completed on 4 North of the main hospital building and 10 Kiil dialyzers were located in this area. This space consisted of approximately 1100 square feet divided so that there would be a supporting laboratory and a patient dialysis area. As many as 6 dialyses can be done simultaneously in this area, with facilities available for dialysis at all times.

Method of Dialysis

Each candidate for dialysis has a silastic teflon shunt (fig. 1) inserted

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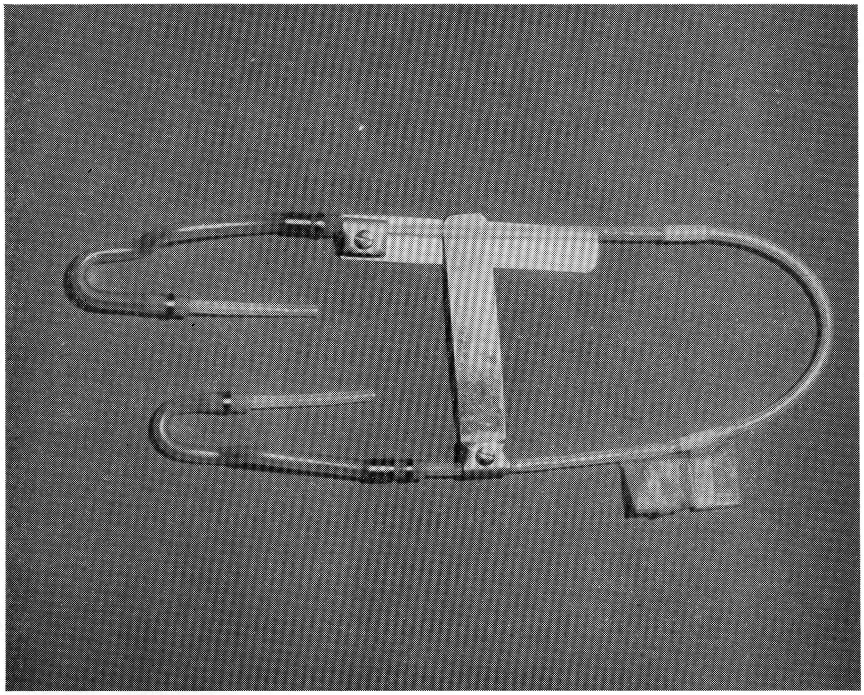

Fig. 1.—Arterio-venous shunt worn by patients that are on repeated dialysis.

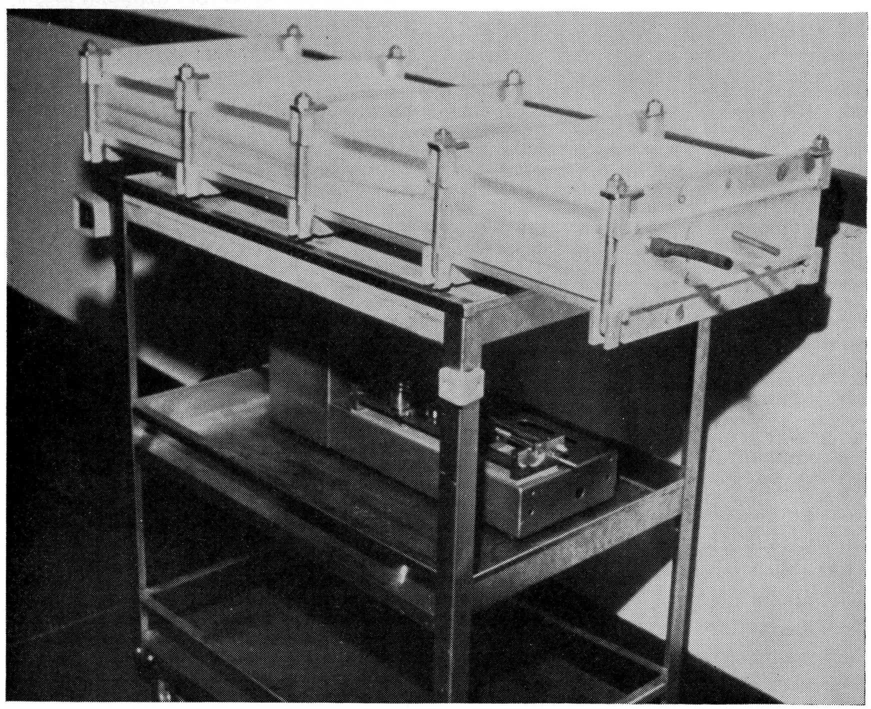

Fig. 2.—The Kiil Artificial Kidney showing the two blood inlets at the middle of the right end and the singly larger bath outlet. The Harvard pump on the second shelf is used to infuse heparin to prevent blood clotting inside the artificial kidney.

under local anesthesia in a small peripheral artery and vein. When the patient is not on the artificial kidney, blood is allowed to flow from the artery into the vein to maintain a constant flow of blood, thereby preventing clot formation. This mechanically exteriorized A-V fistula has not been known to produce cardiac decompensation and it does avoid the need for repeated cutdowns. Before this technique was devised the number of dialyses that could be done in any one patient was limited.

The dialyzer itself (fig. 2) is quite simple in design and function. Its sole purpose is to create a large surface area with a minimum volume of blood out of the patient in contact with the bath solution on the other side of the cellophane membrane. The bath solution consists of a physiologically balanced electrolyte solution plus glucose to adjust the osmolarity. The volume of blood necessary to fill the dialyzer and thereby give 0.9 M^2 of dialyzing surface is only 350 ml. This small volume eliminates the necessity of transfusions when using the Kiil dialyzer. When the patient is placed on dialysis, the A-V shunt is cross-clamped and the continuity of the shunt disrupted. The arterial line of the shunt is connected to the dialyzer inlet and the patient is bled into the dialyzer, replacing the heparinized saline and filling the dialyzer blood compartment. When blood begins to appear in the dialyzer outlet line, it is connected to the venous side of the shunt. Blood then flows continuously from the patient through the dialyzer and back to the patient. At the end of the procedure, the blood in the dialyzer is returned to the patient by flushing it back in with saline. The net loss of blood per dialysis is 30 to 50 ml. Blood pumping is not necessary, but it is done in some centers to speed up the rate of dialysis and reduce the time spent on the kidney. Without blood pumping, it usually requires two 12 hour periods of dialysis per week to maintain an anephric patient asymptomatic of uremia. The rate of blood flow through the dialyzer without pumping is approximately 100 to 150 ml per minute. The bath solution flows at the rate of approximately 500 ml per minute and is then discarded. By running the bath solution through the dialyzer only once and then discarding it, several patients can be run from a single bath source, providing they can all tolerate the same bath composition. This entire procedure is executed by especially trained nurses and technicians, thereby freeing the physician completely. The major role of the physician in a dialysis center is to care for the patients off dialysis, and to decide when dialysis should be carried out. The physician must also occasionally modify the bath formula as deemed necessary according to the patient's individual needs. There is no reason to feel that any physician who has taken the time to make himself aware of the benefits of dialysis and what can be expected of the procedure, should not be able to order this service when indicated.

Results and Discussion

Dialysis with Transplants

During 1962, 15 dialysis were done. Six of these were done in conjunction with the transplant program on 3 patients and the remaining 9 were for acute tubular necrosis and barbituate intoxication on 6 patients. In 1963, there were 195 dialysis done, and in 1964, 507. The great majority of the dialyses in 1963 and 1964 were for the transplant program, using primarily the Kiil kidney.

Between August 1962 and April 1965, 63 renal homotransplants were carried out in 57 patients. Four patients were transplanted twice and one patient had 3 transplants. In order to support this program, 760 hemodialyses were done. The distribution of these dialyses is shown in Table 1.

Most pertinent to this discussion are the data on patients that were never transplanted. These 61 dialyses were done in 11 patients, all of whom are now dead. Five of the first ten admissions to the transplant program died before they could be transplanted. We attribute this to inadequate dialysis facilities. Peritoneal dialysis was used in four of these five patients and these four had significant peritonitis that

TABLE 1
Hemodialysis with Transplantation

	Number of Dialyses	Average dialyses per transplant
Pre-transplant	614	11.6
Post-transplant <2 weeks	39	2.6
Post-transplant >2 weeks	30	6.0
Patient never transplanted	61	5.5
Patients awaiting transplant	16	4.0
Total	760	

contributed to their demise in uremia. For this reason, it is felt that peritoneal dialysis is not adequate to support a transplant program. The remaining 6 deaths occurred evenly distributed over the subsequent 58 admissions. Therefore, by instituting an active dialysis program, the mortality rate prior to transplantation was reduced from 50% to 10.3%. Looking now at the six deaths that occurred after dialysis facilities were adequate, we find that one of these was preventable. This occurred in a six year old male who was being dialyzed for the first time. He was in congestive heart failure and was receiving digitalis. When his serum potassium was lowered by the artificial kidney to normal levels he developed digitalis intoxication and died of ventricular fibrillation. The remaining five deaths pre-transplant were attributable to septicemia in two, brain stem hemorrhage in one, and gastrointestinal hemorrhage in one. One patient refused further dialysis and transplantation.

Dialysis for Acute Renal Failure, Chronic Renal Disease and Poisoning

Since the development of our existing artificial kidney unit, the volume of acute dialysis has likewise increased. As stated earlier in 1962 only 6 patients other than transplant patients received dialysis. This number increased to 9 in 1963 and 15 in 1964. The 24 patients that were dialyzed between Jan. 1, 1963, and Dec. 31, 1964 are divided into three groups. The first group was made up of eleven patients who had acute renal failure with otherwise normal kidneys (table 2). The second group, comprising 10 patients, included those with known chronic renal disease, but with superimposed reversible features (table 3). The third group consisted of three patients with attempted suicide, who were dialyzed to remove the ingested toxin (table 4).

The results of dialysis are most rewarding in acute renal failure. In our own series of eleven patients, seven regained sufficient function to bring their BUN and creatinine back to normal, and in five of these that were

TABLE 2

Dialysis for Acute Renal Failure

	Patient	Etiology	Number of Dialyses	Results†
1	K.S.	Cortical Necrosis, Post-partum Hemorrhage	14	Transplanted, Died.
2	J.C.	A.T.N.*, Gunshot	3	B
3	C.H.	A.T.N., Septicemia	3	A
4	Z.T.	A.T.N., Septicemia	5	A
5	R.J.	A.T.N., Abruptio	1	A
6	C.B.	A.T.N., CCl_4	2	A
7	G.S.	A.T.N., Pancreatitis	1	B
8	W.C.	A.T.N., Ethylene glycol	4	A
9	J.B.	A.T.N., Septicemia	6	Died
10	J.R.	Acute Vasculitis	2	Died
11	M.B.	A.T.N., Hemorrhage	2	Died

** A.T.N.—Acute Tubular Necrosis;† Classification of results: A, GFR > 75 cc/min, B, patient alive BUN and creatinine normal, but no evaluation of G.F.R. available.*

TABLE 3

Dialysis for Chronic Renal Disease with Reversible Features

	Patient	Etiology of Acute failure	Number of Dialyses	Results*
1	E.D.	Iatrogenic Acidosis	1	Lived 6 months
2	J.W.	Pyelonephritis	1	Lived 2 weeks
3	J.P.	Accelerated Hypertension	6	Lived 1 week
4	B.C.	Pyelonephritis	4	Transplanted, Died
5	S.C.	Pyelonephritis	3	Lived 2 months
6	E.L.	Pyelonephritis	2	Lived 3 weeks
7	R.D.	Dehydration	2	Lived 3 weeks
8	A.S.	Pyelonephritis	4	Lived 1 month
9	A.C.	Pyelonephritis, A.T.N.	1	Lived 1 day
10	N.J.	Heart failure due to rheumatic disease	2	Lived 1 month

* Duration of life after last dialysis.

TABLE 4

Dialysis for Attempted Suicide and Intoxications

	Patient	Drug or Toxin	Number of Dialyses	Results
1	E.S.	Combination of Drugs	1	Living and well
2	W.G.	Barbiturates	1	Living and well
3	J.C.	CCl_4	1	Died

checked with creatinine clearance studies, all were found to have a clearance of greater than 75 ml per minute. There were four deaths in this group. Of these, two were probably not dialyzed long enough or frequently enough, as borne out by the fact that they died in uremia. One patient (J.R.) with an acute vasculitis of unknown etiology died with azotemia of a significant degree, but it is not felt that renal failure was the cause of death. The fourth death occurred in a patient with renal cortical necrosis following a complicated delivery. The patient was maintained on the artificial kidney for eight weeks. At the end of this period, an open biopsy of the kidney revealed cortical necrosis. The patient was then bilaterally nephrectomized and transplanted.

In our present state of knowledge, it appears that the prognosis for a patient living through an episode of acute tubular necrosis is more dependent on the prognosis of the underlying disease than on the tubular necrosis itself. In our own experience, we have maintained a bilaterally nephrectomized patient on dialysis in a reasonable state of good health for over 14 months. Scribner et al. now have some essentially anephric patients that are doing quite well after 5 years on dialysis.

In those patients with chronic renal disease who suddenly become decompensated due to a superimposed acute insult, the results are not as good. Here again the prognosis is determined by the underlying chronic renal disease and the availability of chronic dialysis facilities.

Dialysis is very useful in the management of drug intoxication and attempted suicides. First, it promptly removes the offending agent from the blood, and secondly, it shortens the period of unconsciousness, thereby reducing the complications of coma.

Summary

Hemodialysis is a safe acceptable method of treatment for drug intoxication, and acute renal failure. It is also useful in the management of patients with chronic renal disease either on a periodic basis or, intermittantly, for acute exacerbations superimposed on chronic renal insufficiency. The great majority of dialysis at MCV has been done in conjunction with the ongoing renal homotransplantation program. Here dialysis has proven to be an innocuous procedure and has contributed significantly to the success of this program.

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